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Original Article

Prediction of difficult laryngoscopy in obstetric patients scheduled for Caesarean delivery

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Summary

Background and objective: Failed intubation is an important cause of anaesthetic-related maternal mortality. The purpose of this study was to determine the ability to predict difficult visualization of the larynx from the following preoperative airway predictive indices, in isolation and combination: modified Mallampati test, the ratio of height to thyromental distance and the Upper-Lip-Bite test. *Methods:* We collected data on 400 consecutive parturients scheduled for elective Caesarean delivery under general anaesthesia requiring endotracheal intubation and then assessed all three factors before surgery. An experienced anaesthesiologist, not apprised of the recorded preoperative airway assessment, performed the laryngoscopy and grading (as per Cormack and Lehane's classification). Sensitivity, specificity and positive predictive value for each airway predictor in isolation and in combination were determined. *Results:* Difficult laryngoscopy (Grade 3 or 4) occurred in 35 patients (8.75%). The ratio of height to thyromental distance had a higher sensitivity, positive predictive value and fewer false negatives than the other variables tested. The ratio of height to thyromental distance of 21.24 provided the best cut-off point for predicting subsequent difficult laryngoscopy. The odds ratio (95% CI) of the ratio of height to thyromental distance, Mallampati class and the Upper-Lip-Bite test were 127.8 (44.8–364.5), 49.8 (20.3–121.8) and 6.6 (2.29–19.30), respectively. *Conclusion:* The ratio of height to thyromental distance may prove a useful screening test for predicting difficult laryngoscopy in obstetric population.

Keywords: ANAESTHESIA OBSTETRICAL; INTUBATION INTRATRACHEAL; LARYNGOSCOPY.

Introduction

Anesthesiologists involved in the care of the obstetric patient must consider airway management as an essential element. The importance of how well the airway is managed is emphasized in reports of the effect of anaesthetic selection on maternal mortality, with a fourfold increase associated with general anaesthesia vs. regional anaesthesia. Failure to achieve endotracheal intubation is one of the main causes of anaesthesia-related maternal mortality [1]. According to the study of Merah and colleagues [2], there is an eightfold increase in the incidence of failed intubation in obstetrics.

For patients in whom a general anaesthesia is preferable or obstetrically necessary, various factors have been identified, which when present may make intubation difficult. These coexisting factors may be divided into patient features, factors associated with the pregnant state and factors associated with anaesthesia [3–7].

Identification of those patients in whom intubation might be difficult is the ideal that we strive to achieve. Unfortunately, the methods of assessment we currently use clinically do not accurately predict which patients will be difficult to intubate [5]. The Mallampati classification of mouth opening and the Samsoon and Young modified system [8] have

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been reported to change during pregnancy. A pre-pregnancy classification of I–II may advance one or two classes due to the changes discussed above [9]. Savva [10] found that the modified Mallampati test was neither sensitive nor specific enough for routine use in obstetric population.

Anesthesiologists must therefore use their clinical skills to determine which patients will present difficulty with airway management. This should be done as early as possible during labour to allow a management plan to be decided upon should it be necessary to administer an anaesthetic.

Recently, a new simple bedside test to predict difficult laryngoscopy, defined as Cormack–Lehane classification Grade 3 and 4, was found to be superior to the Mallampati classification with respect to positive predictive value (PPV) and specificity and thus accuracy in non-pregnant patients. This new test, the Upper-Lip-Bite test (ULBT), evaluates the possibility of a patient to cover the mucosa of the upper lip with the lower incisors [11]. Grade 1 (the lower incisors can fully cover the upper lip's mucosa) and Grade 2 (the lower incisors can touch the upper lip but cannot fully cover the mucosa) are thought to predict easy laryngoscopy and are compared with Grade 3 of the ULBT (the lower incisors fail to bite the upper lip), which was found to be associated with difficult laryngoscopy.

Another test for difficult laryngoscopy is the thyromental distance (TMD), which varies with patient size [12]. However, several studies question whether the TMD is either sensitive or specific enough to be used as the only predictor of difficult laryngoscopy [10,12–14]. Although Schmitt and colleagues [15] found that the ratio of height to TMD [RHTMD = Height (cm)/TMD (cm)] had a better predictive value than the TMD, no published study has quantified its sensitivity, specificity and PPV vs. other bedside tests for assessing a patient's airway for difficult laryngoscopy in pregnant patients. We, therefore, conducted a prospective, blind study of the predictive value of the Mallampati classification revised by Samsoon and Young vs. the RHTMD and the ULBT methods of airway assessment for difficult laryngoscopy in parturient candidates for Caesarean delivery.

Methods

The study was approved by an institutional Ethics Committee, and informed consent was obtained from each patient screened for eligibility to participate in this prospective observational trial. We then studied 400 consecutive ASA physical status I–III adult patients scheduled to receive general anaesthesia requiring endotracheal intubation for elective Caesarean delivery. Patients younger than 18 yr of age, with obvious malformations of the airway, inability to sit, recent surgery of the head and neck, edentulous or requiring awake intubation were excluded from the study to avoid the introduction of a variable that might independently affect predictability of difficult laryngoscopy. Patient data collected included age, weight, height and body mass index (BMI). A single anesthesiologist investigator with 7 yr experience in anaesthesia carried out the evaluation as described by the original authors. The following three predictive test measurements were performed on all patients:

1. MMT: Samsoon and Young's modification of the Mallampati test [8] recorded oropharyngeal structures visible upon maximal mouth opening. While seated, each patient was asked to open his or her mouth maximally and to protrude the tongue without phonation [6]. The view was classified as (a) good visualization of the soft palate, fauces, uvula and tonsillar pillars; (b) pillars obscured by the base of the tongue but the soft palate, fauces and uvula visible; (c) soft palate and base of the uvula visible; and (d) soft palate not visible [8].
2. RHTMD: TMD was measured from the bony point of the mentum while the head was fully extended and the mouth closed [16]. Then the ratio of height to TMD was calculated.
3. ULBT: The ULBT was rated as class 1 if the lower incisors could bite the upper lip above the vermilion line, class 2 if the lower incisors could bite the upper lip below the vermilion line and class 3 if the lower incisors could not bite the upper lip [11].

Patients, while in the left lateral position, were transferred to the operating room and 30 mL magnesium hydroxide was administered orally before transfer to the operating table. Oral ranitidine 150 mg was given to all the elective cases at the night before and on the morning of surgery.

On arrival in the operating room, routine monitoring, including non-invasive arterial blood pressure, an electrocardiogram and oxygen saturation, were introduced. Induction of anaesthesia was performed in the supine position with left uterine displacement with 4 mg kg^{-1} of sodium thiopental intravenous (i.v.) Suxamethonium chloride 2 mg kg^{-1} i.v. was administered to facilitate endotracheal intubation. Gradually during loss of consciousness, the cricoid pressure was applied to the patients. After disappearance of fasciculations, the patient's head was placed in the 'sniffing position.' Another single anesthesiologist with 7 yr experience in anaesthesia, who was not informed of the preoperative classes, carried out laryngoscopy and assessed difficulty of laryngoscopy at intubation, which was performed with the patient adequately anaesthetized and fully relaxed on the operating room table. Laryngoscopy was performed using a Macintosh #4 blade to visualize the larynx and the view was classified using the Cormack and Lehane (CL) classification [17] without external laryngeal manipulation: (I = vocal cords visible; II = only posterior commissure or arytenoids visible; III = only epiglottis visible; IV = none of the foregoing visible). Difficult visualization of the larynx (DVL) was defined as CL III or IV views on direct laryngoscopy. Easy visualization of the larynx (EVL) was defined as CL I or II view on direct laryngoscopy. Confirmation of successful intubation was by bilateral auscultation over the lung fields and capnography. Cricoid pressure was maintained until the tracheal was intubated and the cuff inflated.

A prospective power analysis revealed that assuming an incidence of difficult laryngoscopy of 5%, 400 patients provide a power of more than 80% to detect an improvement of discriminating power (measured by the AUC of the appropriate receiver-operating characteristic (ROC) curve) of an absolute value of 15% (e.g. from 50% to 65%) with a type I error of 5% and using a two-sided alternative hypothesis. Using these clinical data (the Mallampati score, the RHTMD, the ULBT score and the Cormack–Lehane classification) recorded for each patient, several measures were calculated that have been frequently used to describe the predictive properties of a scoring system. A list of these measures is provided in the Appendix together with a short description and instructions on how to perform the calculations. Most of them can be easily calculated using the data of a 2×2 table. However, additional statistics were added to this list because they provide valuable additional information to appraise the predictive models. One of them, the area under a ROC curve (AUC), was used as the main end-point of the study to decide whether or not the score was clinically useful. A ROC plot was obtained by calculating the sensitivity (true positive fraction) and specificity (true negative fraction) of every observed data value (cut-off value), and plotting sensitivity against $1 -$ specificity (false positive fraction). A value of 0.5 under the ROC curve indicates that the variable performs no better than chance and a value of 1.0 indicates perfect discrimination. A larger area under the ROC curve represents more reliability [18] and good discrimination of the scoring system. In addition, the ROC curves were used to identify the optimal predictive cut-off points for each test. The optimal predictive cut-off point is the point on the ROC curve that is nearest (unweighted distance) to the ideal point (sensitivity = 100%; false positive = 0%). The AUC represents the probability that a random pair of test results will be ranked correctly as to their disease state [19]. Differences between the AUC values of three predictive tests were calculated, and a P value of 0.05 was defined as statistically significant. Patient data were presented as mean ± SD. BMI was determined from weight (kg)/height^2 (m). Patient data and value of the airway predictors were compared using t-tests for continuous variables and U-test for MMT or ULBT. Sensitivity, specificity and PPV were obtained and compared amongst predictors. Secondly, combinations of predictors were formulated. Likewise, the sensitivity, specificity and PPV were obtained and compared amongst the combinations. The data were analysed using SPSS version 14.0.

Results

A total of 400 patients were enrolled in the study. Patients' age, height, weight and BMI are shown in Table 1. There were 264 ASA I and 101 ASA II patients. DVL was observed in 35 patients. There was no failed intubation. There were significant differences in weight and BMI between the DVL and EVL patients (Table 1). The distribution of MMT, ULBT and the Cormack and Lehane grades are presented in Table 2. There were significant differences in RHTMD between DVL and EVL patients by using the U-test (23.1 ± 3.3 vs. 23.5 ± 2.0, respectively, $P < 0.05$). The measures used to describe the predictive properties of the three models are shown in Table 3. The main end-point of this study, the AUC of the ROC, was lower for the MMT (AUC = 0.152; 95% CI, 0.071–0.228) or the ULBT (AUC = 0.395; 95% CI, 0.288–0.501) than the RHTMD score (AUC = 0.604; 95% CI, 0.470–0.739), and the difference of three ROC curves was statistically significant ($P < 0.05$). Predictive values of the three single or combined predictors are shown in Table 3. Using discrimination analysis, a ULBT Grade 3 and MMT Grade 3 were considered as the cut-off points for predicting difficulty. The RHTMD was the most sensitive of the single tests with a sensitivity of 71.4%. The ULBT was the least sensitive of the single tests with a sensitivity of 17.1%. The RHTMD had the highest sensitivity, positive or negative predictive value, and accuracy amongst single predictors. The combination of the three tests decreased the sensitivity, the accuracy and the negative predictive value. The combination with the best results was the Mallampati test–ULBT with specificity, accuracy, the PPV and positive likelihood ratio of 99.7%, 92.0%, 80.0% and 38.0, respectively. The various other combinations resulted in decreased accuracy and

Table 1. Patient characteristics.

	All Patients ($n = 400$)	ELV ($n = 365$)	DLV ($n = 35$)	P value
Age (yr)	24.0 ± 4.8	23.9 ± 4.7	25.0 ± 5.4	0.183
Height (cm)	165.2 ± 5.7	165.3 ± 5.6	165.8 ± 5.5	0.606
Weight (kg)	69.7 ± 10.1	69.1 ± 10.1	74.9 ± 8.8	0.001
BMI (kg m^{-2})	25.4 ± 2.8	25.2 ± 2.8	27.2 ± 1.8	0.000

DVL: difficult visualization of the larynx; EVL: easy visualization of the larynx; BMI: body mass index.
Data are presented as mean ± SD.

Table 2. Distribution of MMT, ULBT and laryngoscopic view of all patients.

Category patients	Number of patients
Mallampati class	
1	156
2	210
3	32
4	2
ULBT	
1	242
2	141
3	17
Laryngoscopic view	
1	223
2	142
3	35
4	0

ULBT: Upper-Lip-Bite test.

the PPV. By using discrimination analysis, the optimal cut-off point for the RHTMD for predicting difficult laryngoscopy was 21.24 (sensitivity, 71.4%; specificity, 98.1%). The multivariate analysis odds ratios (95% CI) of the RHTMD, Mallampati class and ULBT were 127.8 (44.8–364.5), 49.8 (20.3–121.8) and 6.6 (2.29–19.30), respectively.

Discussion

In our study, the incidence of DLV was 8.7%. Rocke and colleagues [5] showed that difficult intubation is experienced more frequently in obstetric units (7.9%) than in the operating suite (2.5%). In the study by Merah and colleagues [2], 10% of Nigerian obstetric patients had difficult laryngoscopy. Variations in the incidence of DVL have been ascribed to various factors, such as different anthropomorphic features among populations, lack of uniformity in describing or grading laryngeal views, cricoid pressure application, head position, degree of muscle relaxation and type or size of laryngoscope blade [20]. In obstetric patients, it is possible that increased weight gain associated with pregnancy resulted in a reduced ability to see the larynx [9]. This would be supported by our finding of an association between reduced laryngoscopic view and weight.

Unanticipated difficult tracheal intubation has been identified as a major contributory factor to anaesthetic-related maternal morbidity and mortality [5,21]. Thus, the search for a predictive test that has ease of applicability and accuracy of prediction (discriminating power) continues. The RHTMD seems to meet these quality factors. Obviously, it is easy to perform as a bedside test. The instructions required for both the observer and the patients are extremely easy, and thus, there is less probability of misinterpretation while performing the test compared with the Mallampati test in which a different manner of performing the test may be used (e.g. performing the test with or without phonation). Analysis of our data revealed that the AUC of ROC for RHTMD was 0.604, whereas the AUC for the corresponding ULBT or Mallampati score was only 0.395 or 0.152, respectively. The accuracy of RHTMD for preoperative prediction of difficult laryngoscopy in nonobstetric population was documented in the study by Krobbuaban and colleagues [22].

Ideally, any preoperative assessment scheme for difficult laryngoscopy should be highly sensitive, specific and possess a high PPV with few false positive and negative predictions. In this study, it was found that the RHTMD was the most useful single predictor with a sensitivity, specificity and PPV of 71.4%, 98.1% and 78.1%, respectively. The advantage of RHTMD is its higher sensitivity than other tests, thus false negative (2.5%) predictions are minimized. The consequence of a false negative result may be deleterious and even life-threatening; therefore, decreasing false negative prediction is far more important than falsely predicting difficult laryngoscopy in unaffected patients. Because difficult laryngoscopy is infrequent, the incidence of false negatives is small. Nevertheless, a test should be sufficiently sensitive to detect possible difficulties with laryngoscopy. Although all the tests in this series were not highly sensitive, RHTMD measurement resulted in the least amount of detection failure for difficult laryngoscopy of the other two tests. This is our most important finding.

Table 3. Predictive values for MMT, ULBT and RHTMD to predict the occurrence of a grade 3 or 4 intubation according to the Modified Cormack-Lehane Classification.

Test	True positive	False positive	True negative	False negative	Accuracy (%)	Sensitivity (%)	Specificity (%)	Positive prediction value (%)	Negative prediction value (%)	Likelihood ratio (positive test)	Odds-ratio/ relative risk	AUC of ROC curve
MMT	22	12	353	13	93.7	62.8	96.7	64.7	96.4	19.0	49.8/2.6	0.152
ULBT	6	11	354	29	90.0	17.1	96.9	35.3	92.2	05.5	6.6/1.1	0.395
RHTMD	25	7	358	10	95.7	71.4	98.1	78.1	97.3	37.6	127.8/3.4	0.604
M + U	4	1	364	31	92.0	11.4	99.7	80.0	92.1	38.0	46.9/1.12	0.444
M + R	13	11	354	22	91.7	37.1	96.9	54.1	93.9	11.9	19.1/1.54	0.329
U + R	3	11	354	32	89.2	8.6	97.0	21.4	91.7	2.9	3.0/1.06	0.472
M + U + R	3	1	364	32	91.7	8.6	99.7	75.0	91.9	28.7	34.1/1.09	0.459

M: MMT; MMT: modified Mallampati test; U: ULBT; ULBT: Upper-Lip-Bite test; R: RHTMD; RHTMD: ratio of height to thyromental distance (TMD). Data are number of patients or derived data.

Furthermore, the likelihood ratio (LR+) for a positive test result may be a useful measure to judge the usefulness of a predictive tool in daily practice [23]. This measure is the number of times more likely that a patient with a positive test result will present with a difficult intubation. The LR+ was 37.6 for the RHTMD, whereas it was 5.51 for ULBT and 19.03 for the Mallampati score.

Using a multivariate analysis, we found that the RHTMD had the highest odds ratio for prediction of a difficult laryngoscopy. Schmitt and colleagues [15] found that RHTMD $\geq$ 25 can be used to predict difficult laryngoscopies for white men and women. They suggested that it might not apply to other races. In our study, a RHTMD $\geq$ 21.24 was a determining factor for predicting a poor laryngeal view among our patients. This difference warrants further investigation to determine the significance of ethnicity. The RHTMD calculation is based on accurate measurement of patient's TMD and height making interobserver variations highly unlikely when using this test (in contrast to considerable interobserver variations found with the MMT, which has been controversial) [5,24]. Many patients involuntarily phonate during evaluation of the MMT score, which may significantly alter the Mallampati classification [20]. Tham and colleagues [25] showed that prevention of phonation was a critical factor in achieving a reliable score. MMT in assessing oropharyngeal view has had poor reliability in the Karkouti and colleagues study [26], which could be attributed to the technicalities involved in the demonstration, and discrepancies in evaluating and interpreting the observations.

The ULBT was found to have a low sensitivity and PPV and was the least useful of the test performed. The ULBT assesses a combination of jaw subluxation and the presence of buck teeth simultaneously [11]. It is possible that physiologic changes during pregnancy cause change in the degree of jaw subluxation.

Safe outcome of anaesthesia remains the goal of every anesthesiologist. There is still no test or group of tests that can predict 100% of difficult laryngoscopies. The RHTMD may be a useful bedside screening test for preoperative prediction of difficult laryngoscopy in obstetric population. Further studies with larger sample size in different populations are recommended for the documentation of our results.

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Appendix

Statistical terms and definitions.

	Patient airway difficult	Patient airway easy	
Test result:			
Airway difficult	A	B	A + B
Airway easy	C	D	C + D
	A + C	B + D	A + B + C + D
True positive	A difficult laryngoscopy that had been predicted to be difficult (A)		
False positive	An easy laryngoscopy that had been predicted to be difficult (B)		
True negative	An easy laryngoscopy that had been predicted to be easy (D)		
False negative	A difficult laryngoscopy that had been predicted to be easy (C)		
Sensitivity	The percentage of correctly predicted difficult laryngoscopies as a proportion of all laryngoscopies that were truly difficult (A/(A + C))		
Specificity	The percentage of correctly predicted easy laryngoscopies as a proportion of all laryngoscopies that were truly easy (D/(B + D))		
Positive predictive value	The percentage of correctly predicted difficult laryngoscopies as a proportion of all predicted difficult laryngoscopies (A/(A + B))		
Negative predictive value	The percentage of correctly predicted easy laryngoscopies as a proportion of all predicted easy laryngoscopies (D/(C + D))		
Accuracy	The percentage of correctly predicted easy or difficult laryngoscopies as a proportion of all laryngoscopies (A + D)/(A + B + C + D)		
Likelihood ratio of a positive test result (LR+)	Gives the number of times more likely that a patient with positive test result will have a difficult airway; it is calculated by sensitivity divided by 1 − specificity.		